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13. ABSTRACT (Maximum 200 words)

During the past year, we have continued our efforts in the area of signal, image and video representation, compression, storage, transmission and enhancement. In the area of video transmission, we have focused on optimal joint/source channel coding for noisy wireless channels. In the area of video compression, we submitted our very low bit rate algorithm to MPEG-4 standardization body inIn the area of video compression, we submitted our very low bit rate algorithm to MPEG-4 standardization body in November of 1995. Our matching pursuit algorithm performed among the top 3 of all the submissions for very low bit rate compression. In the area of video compression, we also focused on low complexity, real time software codecs for scalable video. Specifically, we have shown that by trading off compression efficiency with complexity, we can achieve real time encode and decode capability on today's workstations. In the area of video storage and retrieval, we continued our efforts on placement of Variable Bit Rate (VBR) and scalable video on parallel disk arrays and developed new admission control strategies. These schemes were tested experimentally on a real disk system in our lab. In the area of resolution enhancement, we developed a novel motion estimation scheme for multi-frame video resolution enhancement. Finally, in the area of circuits and systems for signal processing, we continued our efforts on oversampled data conversion systems, such as sigma delta modulators. Specifically, we developed analytical and simulation techniques for locating dominant tones in double loop Sigma Delta A/D converters.

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Summary of Activities for 4/31/95 through 4/31/96

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During the past year, we continued our efforts in the areas of signal, image and video processing, representation, compression and enhancement. In what follows, I will briefly outline our progress in each area.

1 Scalable Video Transmission over Noisy Wireless Channels

We have developed an optimal bit allocation strategy for a joint source/channel video codec over noisy channel when the channel state is assumed to be known. Our approach is to partition source and channel coding bits in such a way that the expected distortion is minimized. The particular source coding algorithm we use is rate scalable and is based on 3D subband coding with multi-rate quantization. We show that using this strategy, transmission of video over very noisy channels still renders acceptable visual quality, and outperforms schemes that use equal error protection only. The flexibility of the algorithm also permits the bit allocation to be selected optimally when the channel state is in the form of a probability distribution instead of a deterministic state [1].

2 Low Complexity, Software Only, Scalable Video Codec

Scalable video compression is becoming increasingly more important in diverse, heterogeneous networks of today. In our previous work [9], we developed a scalable codec capable of generating bit rates from tens of kilo bits

per second to several mega bits per second with fine granularity of available bit rates. This codec is based on 3-D subband coding and multi-rate quantization of subband coefficients, followed by arithmetic coding. In this paper, we will replace the arithmetic coding portion of the codec in [9] with block coding, and compare encode/decode speed of this new coder with MPEG. Unlike MPEG, this codec requires symmetric computational power at the decoder and encoder and as such is useful in software only, real time, interactive video applications. We have found the encoding speed of the new encoder to be one order of magnitude faster than MPEG-1, without significant loss in compression efficiency [3, 4].

3 Video Placement and Retrieval Strategies

In this project, we compare techniques for storage and real-time retrieval of Variable Bit Rate (VBR) video data for multiple simultaneous users. We compare the following three classes of VBR data placement and retrieval techniques: Constant Time Length (CTL) places and retrieves data in units corresponding to equal playback durations, Constant Data Length (CDL) places and retrieves constant-sized data units, and a hybrid solution uses CDL placement but retrieves a variable number of units per user in each service round. We provide a cost analysis of the above techniques and conclude that CTL and hybrid techniques can reduce the total system cost by up to a factor of 3 in comparison with padding the VBR video trace. For read-only systems, CTL has the lowest cost per user. For writable systems, the hybrid technique achieves a good compromise between low cost and low fragmentation.

We also address the issue of admission control policies by comparing three techniques. Statistical admission control uses statistics of the stored data to ensure that the probability of server overload does not exceed a prespecified threshold. Data-limit admission control admits users based on precomputing the total amount of data requested by all users in future service rounds. Ideal deterministic admission control assumes we have control of data placement at the disk sector level to precompute all disk access times. We show that data-limit admission control offers a moderate gain for a moderate increase in implementation complexity. We have implemented a highly accurate full disk model simulator that operates 1000 times faster than the real-time disk,

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making it useful for experiments. Finally, we address multiple disk issues and consider applying our data placement and admission control strategies to an interleaved disk array [5, 6].

In addition to VBR storage and retrieval, during the past year, we considered storage and retrieval of scalable video data; our goal is to maximize to number of users served for a wide distribution of request rates. To this end, we developed the principle of constant frame grouping as an efficient method of storing CBR scalable video. The basic idea behind constant frame grouping is to minimize the number of seeks per access by grouping all the frames in one rate layer together. This results in maximum disk utilization and number of users served. We also showed how to extend this principle to CTL and hybrid data placement for VBR video. We see that scalable video can be used to eliminate disk overload caused by reading VBR video. We consider two uses of scalable video for interactive functions during playback from a video server. The first use is to reduce interactivity delay for a server using deterministic admission control, and the second use is for the for the implementation of true VCR functions [7].

4 Video Resolution Enhancement

This project focuses on the spatial resolution enhancement of a video sequence. In contrast to previous work with grayscale images and highly constrained motion, we have developed a technique for color video frames with general motion. The method consists of determining subpixel motion estimation between video frames and subsequently using these estimates along with the original low resolution frames to iteratively create a sequence of enhanced resolution frames. We have developed a novel motion estimation technique based on determining a set of candidate motion estimates per pixel. Experimental results for video sequences containing general motion have verified our technique. Enhanced frames using this technique show significant improvement in both SNR and perceived visual quality over methods such as bilinear and cubic B–spline interpolation [2].

5 Oversampled Signal Processing

An important factor affecting the performance of $\Sigma\Delta$ modulators is their tone behavior. A recent approach to alleviate the tone problem consists of moving the open loop poles outside the unit circle. In this project, we determine the frequency location of two dominant tones as a function of pole location and obtain a partial characterization of the spectral shape. Audio testing along with a series of simulations are then performed to compare the efficacy of pole placement with that of the more traditional tone removal technique of dithering [8].

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